Welcome to our new

XRP

experiential robotics platform

We offer:

- An online robotics curriculum
- Supplied with robotics kits for the class
- Taught in the programming language PYTHON
- Complete with unique and engaging challenges
- Available to a wide range of schools

Abstract

The goal is to show that by providing a course in Science, Technology, Engineering, and Mathematics (STEM) it can prove to have a positive influence on students otherwise uninterested in the field. The project aims to equip young learners with the skills and knowledge needed to succeed in a rapidly changing world. We plan to do this via a course on Canvas and individual, low-cost robot kits to the students. The hope is to make a meaningful impact on the lives of thousands of young students, opening up new opportunities and encouraging the pursuit of careers in STEM fields.

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Chapter 1: Introduction

As the world continues to evolve around us, the need for students learning Science, Technology, Engineering and Mathematics (STEM) continues to grow. However, even with the growing demand, it is not a required curriculum to be taught at every school globally. Due to this, there are many schools without a STEM course, or even any STEM influence. We believe that the addition of STEM courses brought to schools around the USA or even abroad can have a beneficial impact on the new wave of students, and raise the overall interest of the subject. Teaching STEM at a young age helps with a variety of skills such as teamwork, critical thinking and experimentation that isn't always taught in other classes. Our goal is to provide all the resources for a standard STEM course to be taught, with the idea in mind that any school can receive these resources and begin the course.

One of the most important parts of any course would be the curriculum. This is why we plan to make the curriculum for the course adaptable for any classroom. As we plan to make this a globally taught course, it is well understood that there are many variables we have to handle. For example, the student-to-teacher ratio can vary from country to country or even city to city. With this in mind, we integrated a course that includes challenges and mini-challenges done in group work. The focus of the course in particular is to learn and practice basic level robotics, which means learning about mechanical, electrical and computer engineering. To go along with the curriculum, there will be XRP Robot kits that the students will need to complete their work, which are low expense, and easy to learn. As they learn the basics to building and wiring the robots, they will be required to face challenges that will be graded. For example, one of these

challenges could just be to move the robot forward a certain distance or to make it spin. Students will also learn how to program through either Python or Blockly. Group work, especially practiced at a young age, can help build problem solving skills and a better understanding of the material. In most teaching environments students are encouraged to ask questions when stuck on a problem, but this doesn't always happen. Kids can be shy, especially towards teachers, but as it turns out, group work can help with that since it lets the students ask questions among themselves. Since there is no reliance on group number and size, they can be adjusted to fit the class, making this a very adaptable curriculum. It is also understood that some of the teachers aren't very familiar with robotics, and with that in mind, we will give a support contact to every teacher that plans to run the course. By doing this, if there is ever any confusion on how the material is supposed to be taught, the teachers can reach out to us.

By creating a curriculum and providing the necessary resources to teach the course in many different countries, we are able to establish and provide a STEM education to those who need it. Instead of starting from scratch and creating a new curriculum everytime a new STEM program is started, we will provide an adaptable curriculum and the resources required to teach the course. This will make future STEM programs easier to create and integrate into schools since less time will have to be spent on the content of the classes.

Chapter 2: Background

2.1: Importance of STEM

As the world continues to rapidly advance in technology, STEM remains as one of the most important fields of study. As stated by the National Science Teachers Association (2020), STEM is “an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy”. With this in mind, it's easy to see the possible benefits of teaching these courses at a young age, such as helping them solve problems focused on knowledge application, experimenting, and teamwork (theedadvocate.org, 2019). If more education systems focused on implementing and advertising STEM courses, then more students would have an opportunity to study it, and thus more students will pursue a career in STEM.

One of the main causes of the importance of STEM education on a global level is the rapid advance of technological innovation. Gordon Moore, one of the co-founders of Intel, was one of the first to try to predict the rate of change of technology. His field was in computer work, so he created a formula, Moore’s Law, that the “number of components in integrated circuit chips will double every 18 months” (news.mit.edu/2013). The law was initially created in 1965 to depict the pace of advancement in computer chip strength, but the principle has been broadened beyond its original use and is now considered a principle that can be implemented in any field.

The implementation of STEM into more education systems would not only benefit the students, but over time, it can also prove to be beneficial for the country as well. For example, in 2019, Rwanda introduced a new system called "New Competence-Based Curriculum" for pre-primary up to upper secondary education. This new curriculum focused on creating a knowledge-based and technology-led economy through the use of STEM and Information,Communication, Technology (ICT) led education. ICT focuses on teaching students to use modern technologies including computers, the Internet, radio, television, and others. There is also a focal point on teaching basic computing softwares such as spreadsheets, powerpoints and geological information. There was also a programme introduced known as Rwanda's One-Laptop-Per-Child (OLPC) flagship programme which gave every student a low cost laptop. This was meant to complement the ICT education by allowing everyone to have access to the online material, making it approachable to everyone at the school. Through the likes of the OLPC flagship programme, Rwanda's ICT education has increased by to 64% and 55% in primary and secondary schools, respectively (nepad.org, 2019). This increase in popularity in the ICT course shows that given the available resources and help, more students will want to at least try a STEM course. This goes to show that with the addition of a STEM education infrastructure, students will show more interest in STEM, which means they will be more likely to study that field, and thus the STEM workforce of the country will grow. After this The African Union High Level Panel on Innovation and Emerging Technologies (APET) believed that this implementation in schools could have such a profound effect on the country's future that they have tried to convince other African Member States to include a similar curriculum (nepad.org, 2019).

This example in Rwanda is a much different scenario than the pilot schools that will be worked on here in the USA, however it illustrates the point that if there is more focus to support students with STEM, then overall, there will be more students studying STEM post-grad. Moreover, STEM education not only prepares students for a future career in STEM fields but also helps them develop critical skills that are essential for success in almost any field. Skills such as problem-solving, logical reasoning, analytical thinking, and creativity are all developed through STEM education, making it a valuable addition to any student's education. STEM education also fosters innovation and entrepreneurship, which are vital components of a thriving economy. By encouraging students to think outside the box and find creative solutions to real-world problems, STEM education helps to cultivate the next generation of leaders and innovators.

The importance of STEM education cannot be overstated. It can prepare students for future careers in STEM fields, develop critical skills that are valuable in any field, encourage innovation and independence. By implementing and promoting STEM education, we can ensure that students are prepared for the challenges and opportunities that will face them in the future and build a more sustainable world.

2.2: Setting

In recent years the US has been pushing for greater STEM education in schools. This has been for two major reasons, to improve the math and science scores of US students when compared to international students and to garner student interest to pursue STEM careers. The Organization for Economic Co-operation and Development (OECD) rankings from 2018 show that the US was ranked 32 out of 41 in math and 13

out of 41 in science. While the US's science scores are above average, the scores in math still have room for improvement.

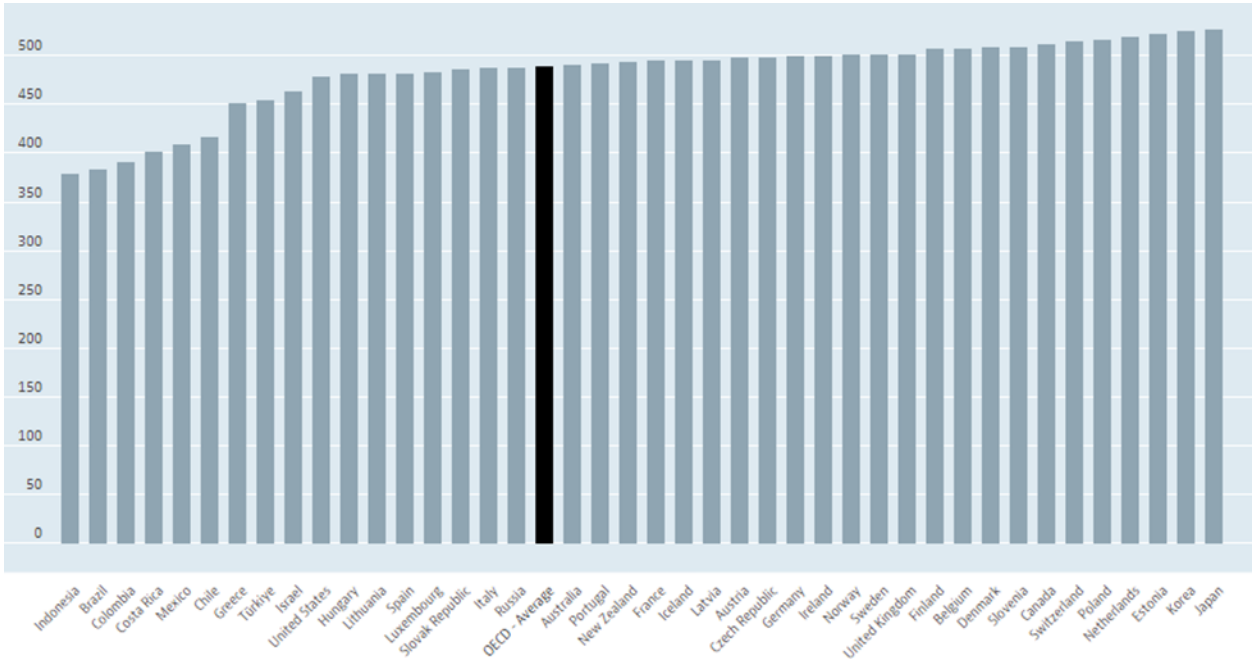


Figure 1: OECD average rankings in math in 2018

https://data.oecd.org/pisa/science-performance-pisa.htm#indicator-chart

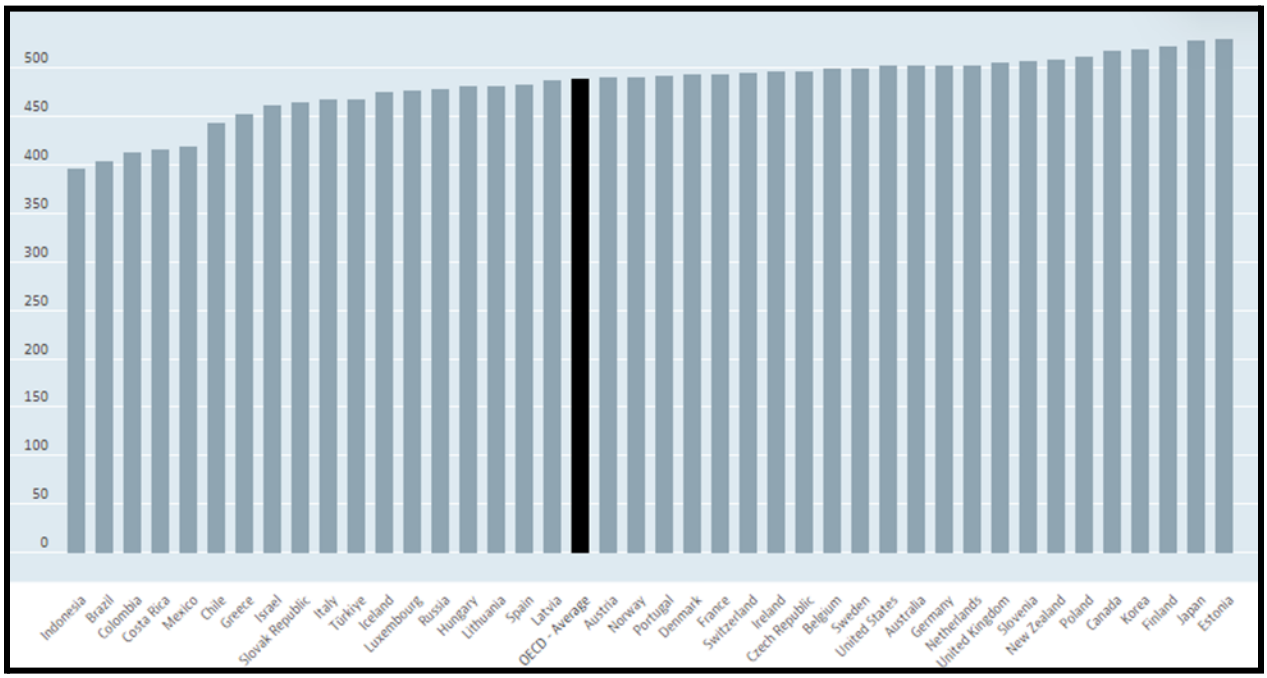


Figure 2: OCED average rankings in science in 2018

https://data.oecd.org/pisa/science-performance-pisa.htm#indicator-chart

The US not only wants students to improve in STEM but also to continue to pursue STEM careers after graduating. With STEM jobs predicted to grow 11 percent by 2031 according to the U.S. Department of Labor, (https://blog.dol.gov/2022/11/04/stem-day-explore-growing-careers#:~:text=In%202021%2C%20there%20were%20nearly,the%20total%20for%20all%20occupations.) there is a continued need for students to pursue STEM jobs.

There is also a disparity with the number of women and minorities who are pursuing STEM education. According to the US Census Bureau (https://www.census.gov/library/stories/2021/01/women-making-gains-in-stem-occupations-but-still-underrepresented.html) women made up only 27% of the STEM workforce in 2019. This number is on the rise but the field is still dominated primarily by men.

Similarly, a study from the Pew Research Center (https://www.pewresearch.org/social-trends/2018/01/09/diversity-in-the-stem-workforce-varies-widely-across-jobs/) showed that African Americans and Latinos made up only 9% and 7% of all STEM workers respectively.

The solution to this problem is to insert STEM education into schools in a way that captures student interest and promotes equality in STEM fields. Robotics has been shown to be a way to garner this interest in STEM. A study by Sevda Kucuk for the International Journal of Child-Computer Interaction (https://www.sciencedirect.com/science/article/pii/S2212868920300039) shows a correlation between the interest in Robotics and an interest in STEM showing that robotics courses can create an interest in other STEM courses. The study also concludes that while interest in robotics was slightly favored toward boys the attitude for STEM afterward was not affected.

Recently, WPI has just unveiled the XRP robotics program in Geneva, Switzerland. This is a low cost robotics system that was developed to bring hands-on robotics education to many places around the world. Since robotics has been proven that it is a great way to get kids excited about STEM education, WPI hopes to incorporate this course into many schools in the US and around the world where there is a lack in STEM education. The XRP robotics program is still in its early development with only one pilot course in place at the moment and more to come. This project aims to find a way to select other pilot schools and analyze the data from them to ensure the XRP Robotics course success.

2.3: Significance of STEM Education

As we continue to make strides in advancing scientific and technical knowledge, the demand for more STEM-focused jobs and careers rises as well. Employers all over the world are looking for more educated employees in order to get better returns on their investment, and as a result, demand for more in-depth knowledge of STEM topics is high. However, one of the major global problems for STEM education worldwide is a disparity between the skill levels of workers available and workers needed. For instance, many potential employees are underqualified due to the lack of presence of STEM education, and the ones that are knowledgeable are actually overqualified for the mid-level tech jobs most employers are offering. In addition to this, a fair amount of the highly qualified workers who are present leave to search for employment opportunities elsewhere, instead of using their knowledge and talent to help contribute to STEM progress in their area. As a result of this, less people are provided with the necessary knowledge to help contribute to STEM progress in their area, which leads to fewer opportunities and more incentive to qualified workers to seek employment abroad.The importance of STEM education goes beyond just filling the demand for jobs. STEM skills are essential for innovation and progress in fields such as healthcare, energy, and technology. With the global population constantly increasing, and with it, the demand for resources and energy, it is important for people to understand and be able to tackle complex problems related to the environment and sustainability. Additionally, STEM education has the potential to create new technologies and industries, providing economic growth and better living conditions for people.

Another significant aspect of STEM education is its impact on diversity and equity. Women, people of color, and people from low-income backgrounds are often underrepresented in STEM fields. Providing equal access to STEM education can help to break down these barriers and create more opportunities for people of all backgrounds to pursue careers in these fields. This not only benefits individuals, but also helps to create a more diverse and inclusive STEM workforce, leading to more innovative solutions to problems that affect everyone.

In conclusion, the significance of STEM education cannot be overstated. It is crucial for filling the demand for jobs in the evolving workforce, advancing progress in important fields, and promoting diversity and equity. However, there are still many challenges that must be addressed, such as the need for more qualified workers and the underrepresentation of certain groups in STEM fields. By prioritizing STEM education and working to create more opportunities for all individuals, we can ensure a brighter future for everyone.

2.4: Curriculum Development

Considering that this curriculum is meant to be distributed on a global scale to potentially thousands of students, it's vital that the course can be easily taught and accessed by anyone, anywhere. For this reason, it was decided to use the course management system Canvas rather than its other large competitor, Blackboard.

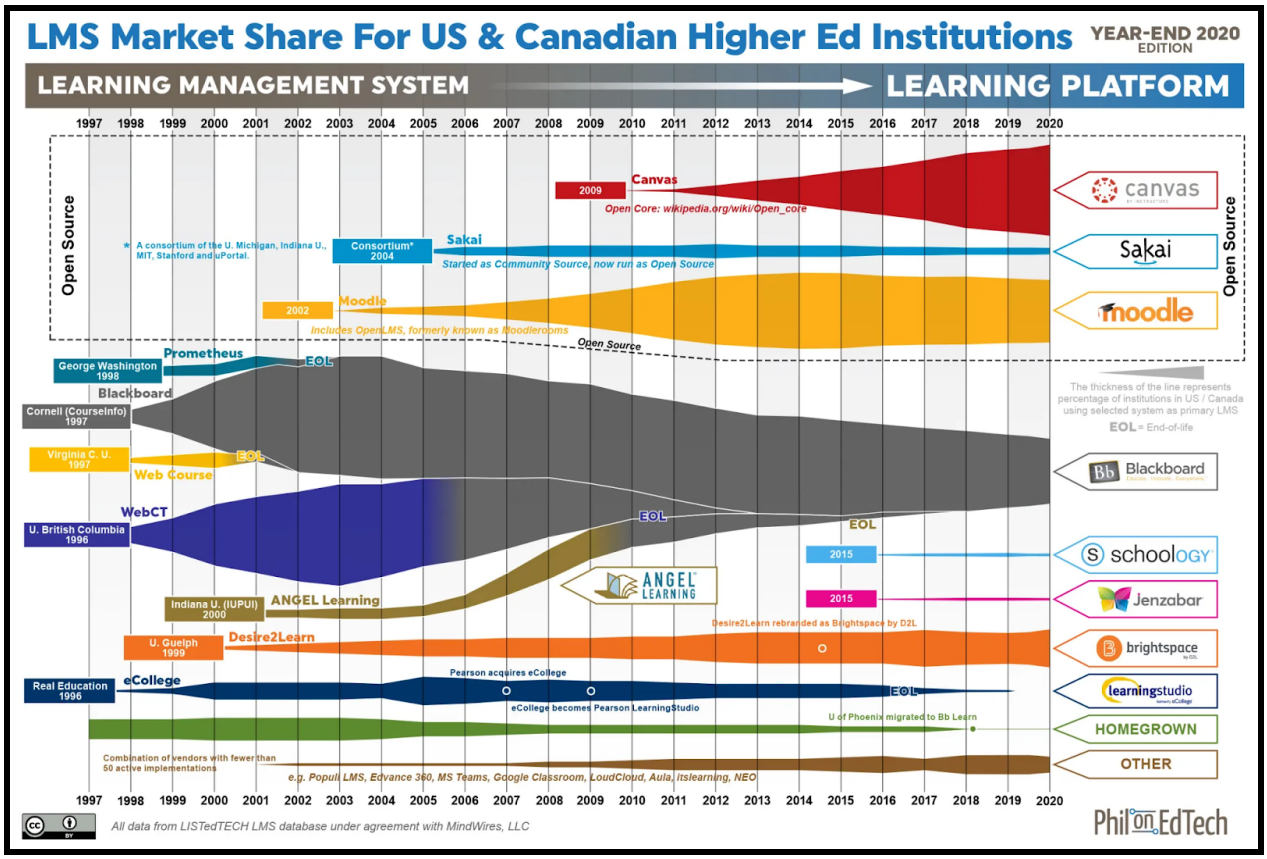


Figure 3: (philonedtech.com, 2021)

According to figure 3, Canvas is the most widely used course management system in America and Canada. Canvas leads with 32% of US & Canadian higher ed institutions using it, followed by Blackboard at 23%. For students, Canvas is touted as one of the best course systems to collaborate on between students, for educators Canvas has a tool called “Speed Grader” which is supposed to make the grading process much more convenient than other platforms (news.elearninginside.com, 2018).

EDUCATION ASPECT	TRADITIONAL LEARNING	PROJECT BASED LEARNING
Curriculum	Content	Comprehension
	Knowledge about facts	Understanding of concepts and principles
	Learn "building-block" in isolation	Developing skills on complex problem solving
Scope and Stage	Follow the curriculum strictly	Follow learners' interest
	From block to block or unit to unit	Larger units are formed from complex issues and problems
	Centered, based on discipline	Diverged, interdisciplinary
Role of lectures	Lecturing	Provide source of learning materials and participant in learning
	The master	As partner
Assessment	Product	Process and product
	Score from tests	Real achievement
	Comparing one another	Standard performance and development from time to time
	Reproduction of information	Demonstration of understanding
Learning Materials	Text, lecturing, presentation	Authentic sources, textbooks, interview, documents, etc.
	Activities and worksheet developed by teachers	Data and materials developed by students
Technology Used	Supporting, peripheral	Main, integral
	Teacher centered	Student centered
	For extensive teachers' presentation	For extensive students' presentation or strengthen learning
Classroom Context	Students work by themselves	Students work in groups
	Competitive	Collaborative
	Students get information from teachers	Students construct, contribute, and synthesize information

Figure 4:

When creating the curriculum that is so heavily focused on programming and robotics, it's important that the students fully grasp the concepts they are taught, which is why there needs to be a balance between traditional and project based learning.

Traditional learning will always be necessary for teaching the students the basic principles of any subject, but there are many benefits to implementing project-based-learning within a course, especially a STEM class. For starters, it's an easy way for students to collaborate and exchange ideas amongst each other. Students would be more willing to ask questions in a project centered class, rather than having to raise their hand in the middle of class, allowing for more focused help from the teachers. Projects are a superb way of letting a student apply what they know in a scenario,

where there isn’t the stress of taking a test for example. In general, including projects and challenges throughout the course will help with student engagement, increase student-teacher interactions, and help provide structure to the curriculum.

The one crucial flaw to using a LMS such as Canvas is that the internet access is required to work on it from home. Considering that this is meant to be taught to anyone, anywhere, it's important that the students from more rural areas can learn and practice from home without the internet. This is why we will use the learning platform Capillary, a training app platform backed by Allogy designed to be distributed to students at school, and then can be accessed and used at home. Allogy has been around since 2009 and is a platform that has helped with making apps for the Defense Health Agency’s and for making a training application for the LAPD to name a few. Capillary’s Creator CMS lets administrators manage Android, IOS and Web apps.The instructor's LMS supports formal and direct learning through a system of levels.

- Branch - Creator, Instructor, Administrator, and Learner portal.
- Workspace -Where the application is used
- Collection - top-level of organization for content within your workspace
- Collection Shelf - Three different types of collection shelves: content, collection, and banner, all meant to organize information
- Content Shelf - Location specific content in one area

Considering that this management system has been tested before, can be used offline and is well thought out and organized, it seems as though this is the best Application Management System to use for this situation.

2.5: Stakeholders

The Primary stakeholders in this project are the people who are in charge of the XRP Robotics program. The pilot schools and the teachers and students of the pilot courses are also stakeholders in this project. The final stakeholders for this project are the schools who will run the XRP Robotics programs in the future.

This project will affect the people who are in charge of the XRP Robotics program since our project will be providing them feedback from pilot courses that will help them improve the course. They will be able to use data collected from the teachers and students of the pilot courses to see if they are effective. Using the data they can then improve the course so that when the pilot courses are over it will be as effective as possible. Not only will our project be able to provide them with data on the current pilot courses but it will also provide the means for schools to apply to run the pilot course. By providing an application based on the criteria that would make them a favorable school for the pilot course, our project will be able to filter schools so that the people in charge of the XRP Robotics program can more easily find eligible schools to take part in the pilot courses. This will save them time and allow them to run pilot courses in schools that will provide them with the feedback they need.

The pilot schools are also stakeholders in this project since we are collecting feedback from them. They are also the ones who will be applying to become pilot schools based on the criteria we have determined necessary to be a good pilot school. The teachers of the pilot course are the primary way that we are getting feedback on whether or not a pilot course was successful. They will be provided surveys before and

after the pilot course to determine any uncertainties in the material or any problems that can be fixed. The students will also be given surveys to determine if the course had the desired effect. One last stakeholder are the schools who will be using the final version of the XRP Robotics course. The data that we collect from the pilot course will be used to ensure that the final course will be released in the best state possible.

2.6: Conclusion

The need for STEM in US education is important for many reasons. With benefits for the individual since STEM is an important field of study and is the backbone of many career choices in the modern world. It also benefits the US by increasing our math and science ranking compared to other countries. However, many schools don’t have access to quality STEM education and the demographic of those in STEM jobs is skewed toward white males. WPI has been committed to solving this problem and with the recent release of the XRP Robotics platform this is more achievable than ever before. Our project will allow the release of the XRP Robotics program to be as successful as possible so many schools are able to implement the program easily.

Chapter 3: Methodology

3.1: Goals

The goal for our project was to develop a way to get valuable feedback from the XRP Robotics pilot courses and to develop a way to determine if schools have the right requirements to be a pilot school for the course. To get the data we needed we focused on what makes the course successful and what requirements a school needs to become a pilot school. In order to meet these objectives we focused on the following research objectives:

1. Familiarize ourselves with the XRP Robotics program to better understand how the pilot course is run.
2. Understand what goes into teaching the course and what would make it successful so we could understand what data we needed.
3. Understand what the XRP Robotics program is looking for in its pilot schools to create the necessary requirements.

Throughout this chapter we lay out the methodology used to gather and analyze information from stakeholders and other important resources, and how we utilize our conclusions to develop effective ways to gather feedback from the pilot courses. In addition to the research objectives mentioned, the goal of this course is to improve the overall quality and effectiveness of the XRP Robotics pilot courses. This includes identifying any areas of improvement in the course curriculum or teaching methods, and developing strategies to address these issues. The feedback gathered from the pilot courses will be used to make data-driven decisions about how to improve the program.

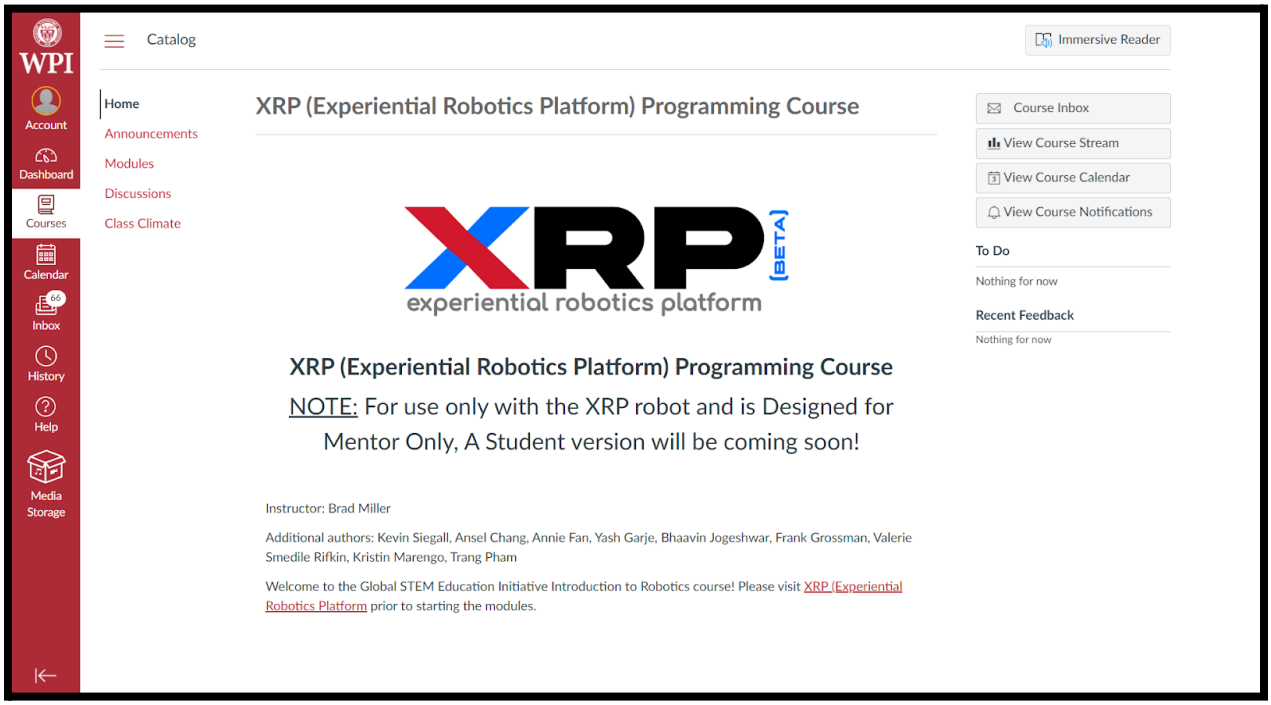
Another important goal of this project is to ensure that schools selected to participate in the pilot courses meet the necessary requirements. This involves identifying the key factors that contribute to a successful pilot school, and developing a set of criteria that schools must meet in order to be selected.

Overall, the goal of this project is to improve the XRP Robotics program by gathering valuable feedback and ensuring that pilot schools meet the necessary requirements to effectively implement the program. This will ultimately lead to a better learning experience for students and improved outcomes for participating schools.

3.2: XRP Robotics

The XRP Robotics course is designed to be intuitive enough so that a student with little to no knowledge of robotics can take this course, and by the end of it, drive a

robot.



The course as a whole is split up into five different modules:

- Introduction
- Getting to drive the robot
- Measuring distances using sensors
- Navigating by following the lines
- Manipulating objects in the environment

The purpose of the introduction is to get the students acclimated with the programs and to understand the basic concepts of robotics. This section is important for laying out the groundwork for students to learn off of, and they will be quizzed at the end of the module.

For the next section, the students will be introduced to slightly more difficult topics such as Effort vs Speed, and they will continue to work on simple coding

commands. By the end of this section, the students will be expected to get their robot to drive.

In this next module, the students will learn how to measure a distance from a sensor on the robot using Python.

For the navigation module, the students will be expected to utilize the sensors on their robots. They will need to have their robot recognize a reflective strip on the ground and follow it in a straight line.

In the final module of the XRP Robotics course, students will learn how to utilize the sensors in their environment using their robot. This section will require students to use their knowledge of programming and robotics to get their robot to perform specific actions, such as picking up a small object and moving it to a specific location.

Throughout the course, students will be provided with various resources to help them learn, including online tutorials and videos, as well as hands-on projects to reinforce their understanding of the concepts covered in the course. The XRP Robotics course also utilizes a project-based approach, which means that students will be working on projects and assignments throughout the course that are designed to challenge and motivate them to learn.

In addition, the XRP Robotics course is designed to be flexible. This makes it an ideal choice for individuals who are looking to learn new skills while balancing other commitments, such as work or family responsibilities. Overall, since the course is adaptable to most students, there will be more opportunities for this program to grow.

3.3: Pilot Requirements

In order to get the best feedback from the pilot courses we first need to determine what requirements make a school eligible to become a pilot school. This is to ensure that the feedback that we get will actually be useful since the pilot schools will be a similar environment to the schools that the course is designed for.

To get a baseline of what the XRP course is looking for we talked to Nick Greeley who is currently working very closely with the first pilot course at English High School in Boston MA on behalf of the XRP Robotics Program. In this interview we focused on information that would allow us to better understand the types of schools, teachers, and environments that the XRP course is looking for in its pilot courses.

In the first half of the interview we focused on what requirements the XRP Robotics program was looking for in the pilot schools and what the current pilot school had that made it a candidate to run the pilot course. Some things we got from this were that the schools they were looking for are not necessarily top schools since the XRP Program is more focused on the schools that don't have advanced STEM programs. This doesn't mean that there are no STEM programs since the current pilot did have a prior STEM course that was not sustainable. This also meant that the teacher for the course had some prior experience teaching STEM classes so it would be easier to transition into teaching the XRP Robotics course.

In the next part of the interview we asked questions about the current pilot course to get a better understanding of the process that was gone through to set up the course. The course itself was run as a regular course offered to students during a normal time but it could also be run as an after curricular activity and the prep would likely be the

same. Before the course was started the teacher was trained on the curriculum for the course so that they had a thorough understanding of the material. The teacher also had a way to contact the XRP team to get help if they needed it throughout the duration of the course. For the materials needed to run the course, Nick advised a 1 to 1, student to robot ratio and no more than 1 to 2. The current pilot course also used MakerPi logic boards for the robots which were easy to replace if needed although future courses will make use of a custom board.

At the end we asked a few questions about difficulties or changes that Nick would recommend based on his experience with the first pilot. He said that the course itself ran smoothly and there were no problems providing the robots and materials as well as communication with the teacher. One recommendation he made for future pilot courses would be the use of educational videos to supplement the content of the course.

The notes from this interview can be found in Appendix B.

Using the information that Nick Greeley and Charlotte Corbette provided us with on the current pilot course we were able to determine what requirements potential candidates for future pilot courses would have to have in order to get the feedback that the XRP program needs to be successful. We determined that we would first need some basic contact information of the pilot school so that we would know what school it is, where the school is, and who the teacher is and how we can contact them. We also asked for some background on the school which included the primary language the students spoke, how many robotics courses are currently being offered and for a description of the classes if there were some. While the school doesn't need any prior

experience with robotics courses, if they have some experience with them it will help when training the teacher. We also need to know the language so that we can provide material that the students and teacher can read. Currently the course is designed to be taught in English so we also ask if the class can read and write in English specifically. The questionnaire itself will also have to be provided in several languages to accommodate this.

We then ask several questions to gauge the schools capability of running the course. We need to know if the school has a plan to implement the course and accommodate for the space needed and for the time to complete it. We also ask about the level of students taking the course and if the school will implement it as a stand alone course or part of an existing course. It is also important that the school has wifi access since the course content is primarily online. Having a teacher who is qualified to teach a subject like robotics is another thing that is needed for the course to run so we ask if they have experience in the necessary categories. The last thing required is the funding to be able to afford the materials so we ask how many students would be taking the course and if they have the budget to afford a robot kit for every student.

The last things on the questionnaire are any additional resource the school might need or any questions that they might have regarding the course. We also ask the teachers if they would like professional development to better prepare for the course. The full questionnaire can be found [location of the questionnaire in the final report].

3.4: Teacher Interview

In order to get a better understanding of the course through the eyes of a teacher, we contacted Ms. Charlotte Corbett who taught the XRP robotics course at the Boston Public Schools. The goal of the interview was to obtain more insight on what worked in the course, what didn't, and what are some problems that we can address within the course. After conducting the interview with Ms.Corbett , our group identified a few key aspects we need to improve upon in the course.

Corbett acknowledged that there is a clear gender bias in STEM education, with a significantly lower number of female students taking her class compared to male students. To address this disparity, she suggested offering courses focused on app development specifically for female students. Corbett recognized that some of her students face constraints due to their socioeconomic backgrounds, which limits their access to resources. Some of the issues can be dealt with via help from the school, but that can't always be expected. Corbett highlighted the effectiveness of project-based learning especially with engagement from students. This course was structured to be very hands-on, so this positive feedback from them lets us know the students were having fun with it. By providing real-world challenges and hands-on activities, students were motivated to learn and some even felt persuaded to pursue in the field of engineering/programming. One of the examples that Corbett mentioned was that she had been donated an EOD (Explosive Ordnance Disposal) from the local fire department that was used in Iraq. She demonstrated it in front of the students by taking items out of her backpack, which certainly must add engagement. Mrs. Corbett also noted that MIT uses a system known as scratch. This is to ask questions between other

students and teachers in terms of coding. Overall, from the teachers perspective of this course, it works well at keeping the students attention, but the pace needs to slow down.

Overall, the interview with Mrs. Cobert provided valuable insight into the XRP robotics course, highlighting areas that need improvement. By addressing these issues, we can make the course more effective and engaging for students, allowing them to gain a better understanding of robotics and programming.

3.5: Nick Greeley Interview

By interviewing Nick Greely, we were able to effectively identify the questions we needed to be asking in our surveys to get the most information on the course's success. For instance, we learned from Nick the general requirements and qualifications that were examined when choosing a pilot school for the course. This gave us a general idea as to the potential background the students and teachers had with these subjects. We also were able to determine what parts of creating the course were problematic, and thus allow us to identify and modify those implementations. Lastly, our interview gave us the general idea of what to look for/ask about to get ideas about the course's success, namely the presence of positive feedback, and ideas on how we can work to improve it from there.

3.6: Survey/ Data Collection

To receive feedback to improve the course, it was decided to survey the students at about the halfway point in the course. This is a crucial step to perfecting the course, because it could be hard to predict some issues of the course and how it works within the classroom. The main areas of concern that we wanted to address were the engagement, the content, and the pacing of the course. These questions were done in the form of multiple choice and short answers, making the data easy to observe and analyze.

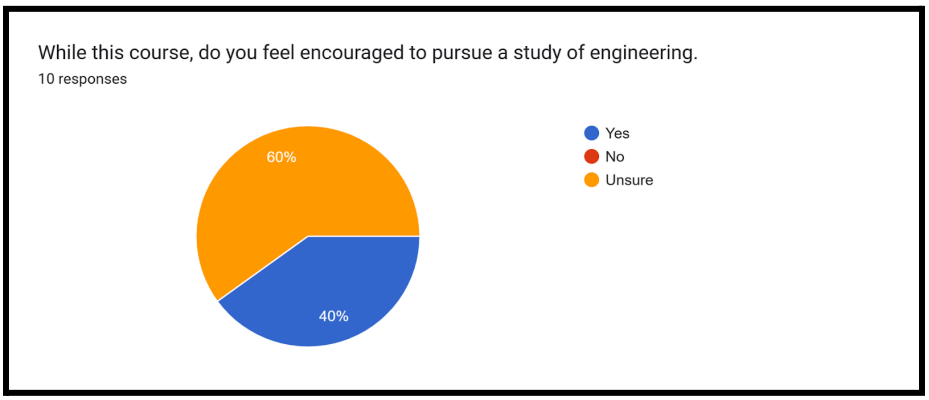
Chapter 4: Results

4.1: Mid-Course Survey

The XRP mid-course survey was conducted on May 8th, 2023 in Mrs. Cobert's classroom. There were 14 students in total that took the course, however, Mrs. Convert indicated to us that 4 of the students were seniors that simply lacked interest and effort in the course so she suggested we don't use their input. Mrs. Cobert also responded to the survey to give her insight. One of the students in the class primarily speaks spanish and is limited in english, so to accommodate we also made a spanish version of the test. The Spanish translation was verified by the Prof. Ingrid Matos-Inn of WPI. To consolidate the data to a short frame, the multiple choice data will be presented and the short answer data will be summarized.

Multiple Choice Responses

Question 3:



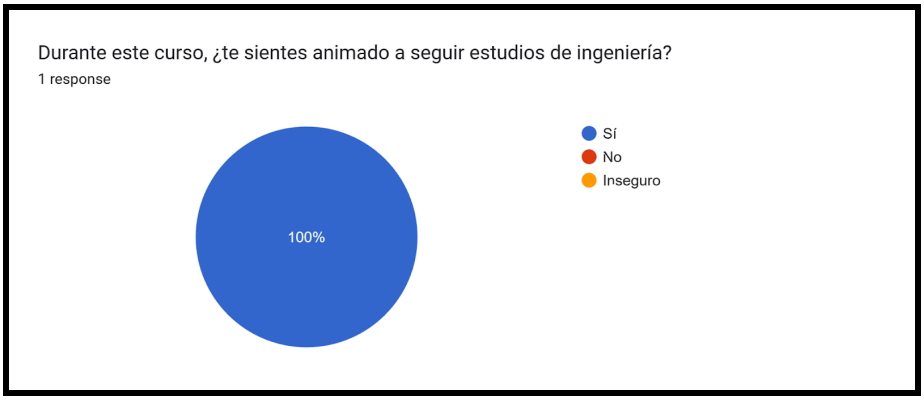
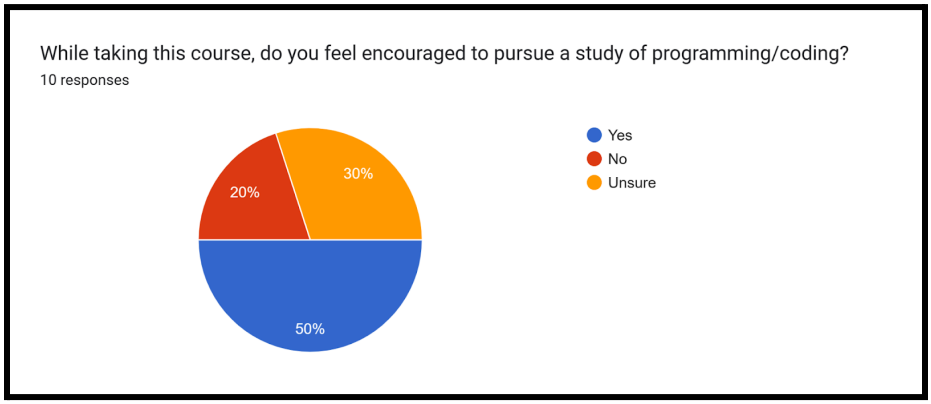


Fig. 5: Student responses on whether they feel encouraged to pursue an engineering degree after the course.

Question 4



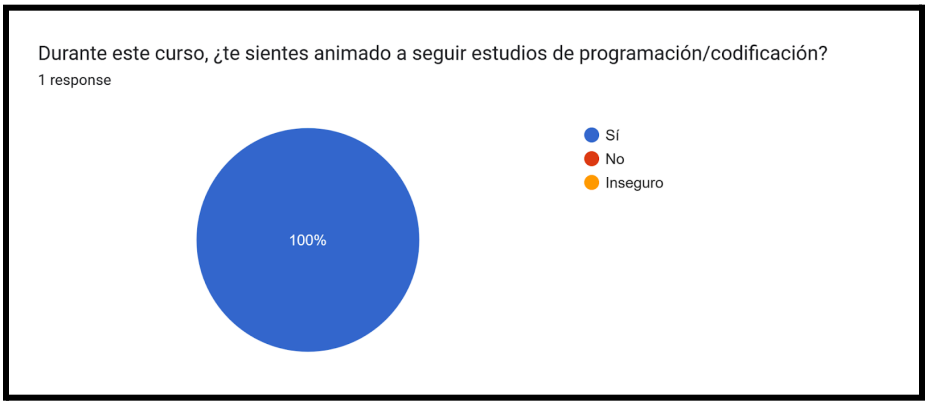
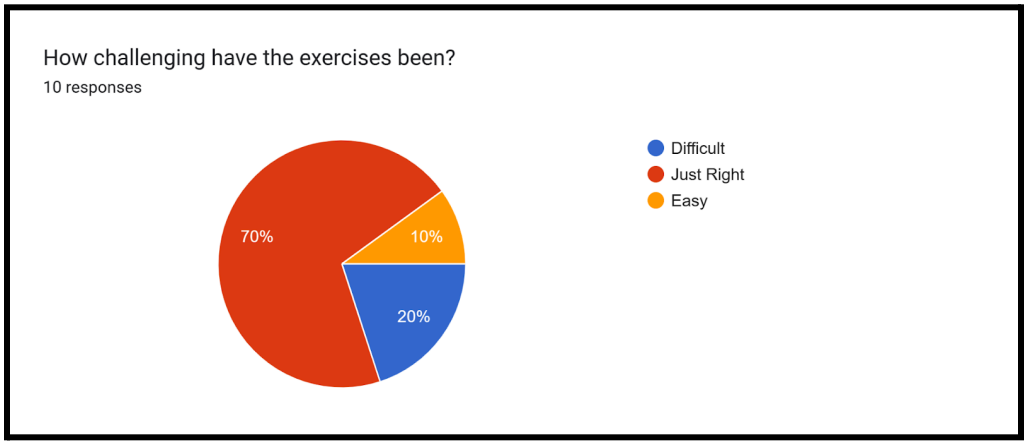


Fig. 6: Student responses on whether they feel encouraged to pursue programming studies after the course.

Question 5:



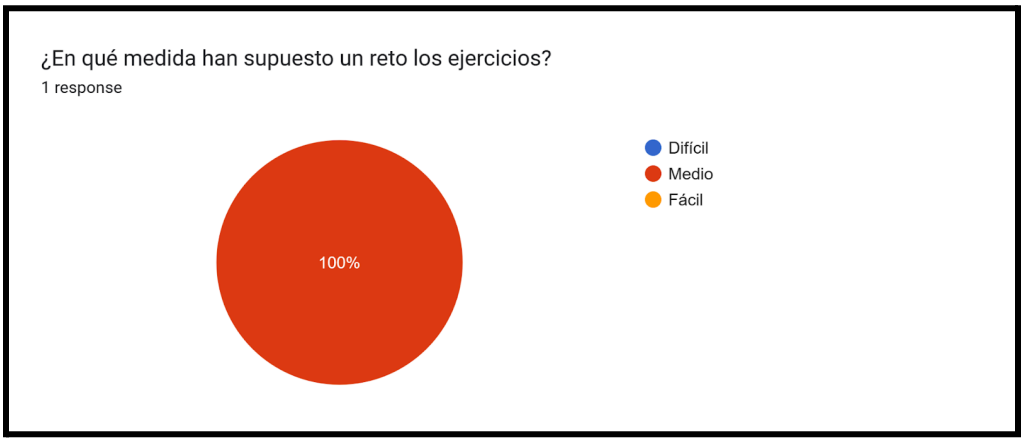
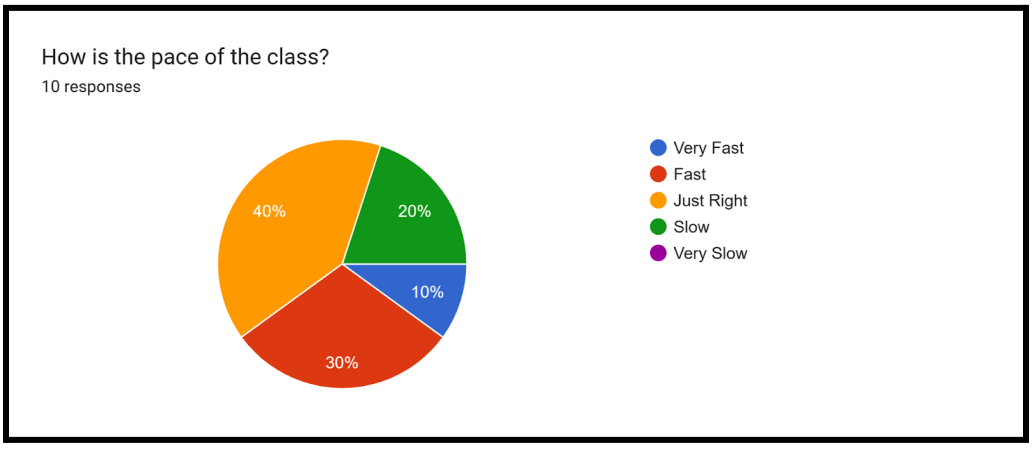


Fig. 7: Student responses on whether they feel the course was easy, difficult, or appropriately challenging.

Question 6:



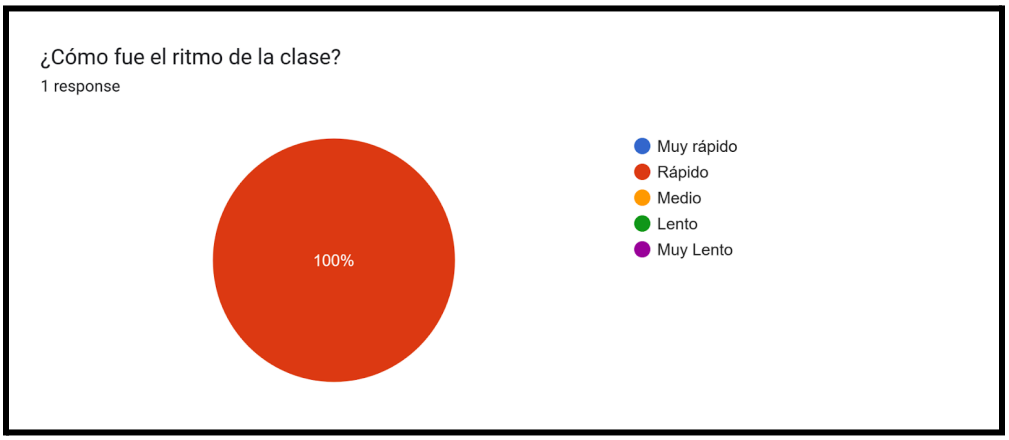
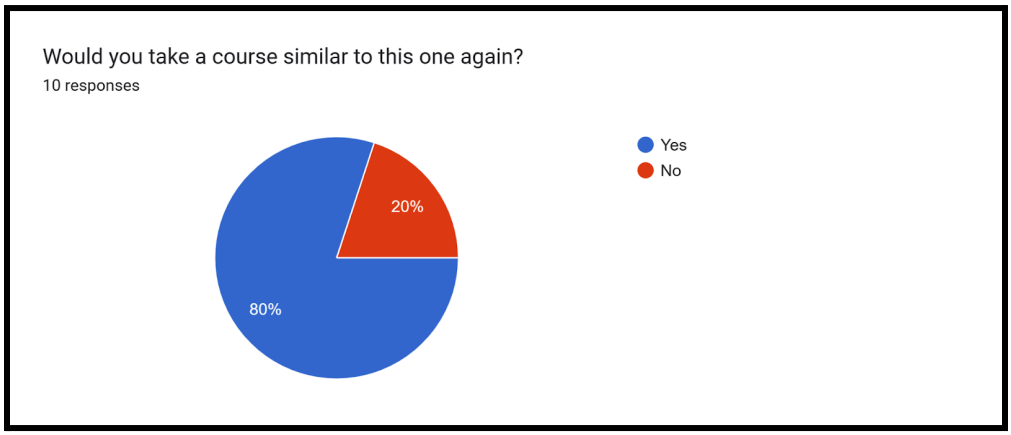


Fig. 8: Student responses on whether they feel the course was paced quickly, slowly, or appropriately.

Question 10:



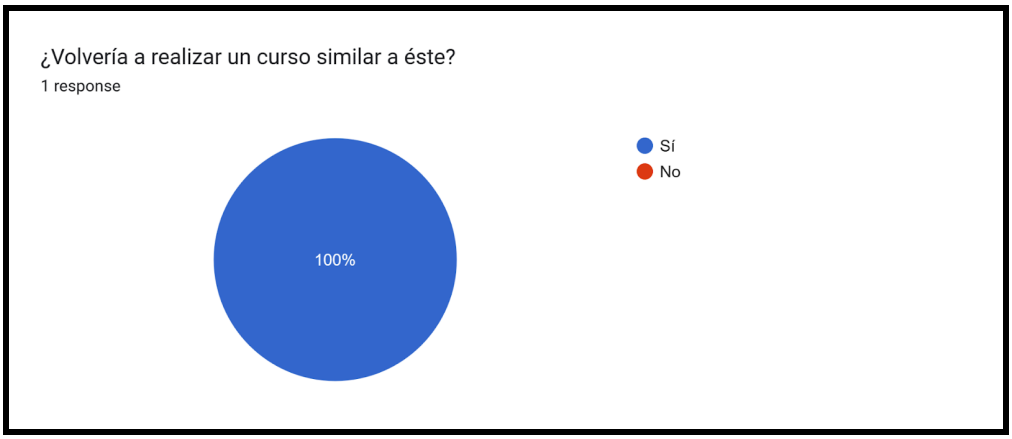


Fig. 9: Student responses on whether they would want to enroll in/take a similar course.

Summary

To summarize this data, this course is a robotics course and although it tends to focus on engineering and promote it, a lot of the work done in this course is through coding, and the results show that. The challenges and activities in the course seem to have worked as a majority of the responses answered that the work was just right and not too difficult. This is great to show the work seems to be balanced between too challenging and too boring, making it engaging for the students. However, a majority of the courses responded that the course was too fast, which will affect how long these courses will; be planned out in the future. Overall, a majority of the students would take this class again, showing that it is fun and while being educational.

In addition to the responses above there were also some short answer questions that we asked. Question one was, What topics from the course have been difficult for you to understand? There was only one response where everything was understood and the rest were a variety of different topics covered in this course. There was no topic that appeared more than the others leading us to the conclusion that there were no

topics in the curriculum that had any problems with being understood due to problems with the content provided. Instead, the difficulty in understanding was more on the individual level and can be solved mostly through help provided by the teacher.

The second question was, What parts of the course have been keeping you interested and engaged? While the answers varied in what activities made them engaged, the one thing that they had in common was that it had something to do with the robot. Whether it was controlling the robot, building the robot, or solving a problem with the robot, the interaction with the robot was the key thing that kept the students engaged. This further proves that robotics is an effective way of getting kids excited and engaged in STEM courses.

We then ask what the students favorite and least favorite activities from the course were in two separate questions. For the students' favorite activities we again see that things to do with the robot such as programming or building, as well as specific challenges for the robot are all prevalent in this list. Again, this shows that the robotics aspect of this course is great for getting kids interested in STEM. For the least favorite activity the results varied from having to keep fixing the robot, to not being able to figure out a certain challenge, to some students not liking having to use certain sensors. What we gathered from this is that if the students have to keep fixing robots or the challenges are too hard then students might start losing interest. Although the other results we have suggest that the challenges are mostly in the right place in terms of difficulty.

The final question on the survey asked for one thing that the students would change about the course. Some of these things are out of the control of the pilot such as kids not liking the teacher. One thing that came up a few times was more help and

more hints. This could either be something to do with how the teacher decided to teach the course, which we would only be able to provide guidance on when to give hints, or the curriculum not providing the proper information for hints.

4.2: Takeaways

After examining the results from the survey, it can be concluded that the XRP class does promote engineering and programming in an engaging way. However, only about half the students responded saying they felt encouraged with pursuing either field of study. This means about half the students responded saying they felt unsure about whether they felt encouraged or not, and 20% responded saying they did not feel encouraged to pursue the field of programming. The difficulty of the class seems to be in the perfect spot, as over 70% of the class believes that the exercises done in the class were “just right” in terms of difficulty, making this appealing to the majority of students. The pace of the class, however, was not as spot on. Although 30% of the English survey answered that the pace of the class was “just right”, 40% of those students and 100% of the responses from the Spanish survey responded that the class was fast. Since a majority of the class views the class as too fast, it would be optimal for future classes if the pace was slowed by a little. An overwhelming majority of the class said that they would take a class like this again. This shows that although this class can be challenging, it's engaging with the students and can be fun.

Conclusion

The goal for our project was to make the launch of the XRP robotics program as successful as possible. To do that, we looked at the first pilot course of the XRP Robotics curriculum, and through data collected from the teacher and students, determined if it was successful and how it could be improved. We also created a set of guidelines for determining a school's eligibility for future pilot programs and a set of surveys to collect data from the teachers and students of those courses so we can continuously improve the curriculum. While we were only able to collect data from one pilot course during our project, the product we have developed will allow the XRP Robotics team to more effectively gather the data needed to support the release of future courses.

Appendix A:

Teacher Interview transcript:

Kellen: All right So what are some of the common challenges you face as a stem teacher and how did you overcome them.

Corbett: So just in general not about the W the XRP this is in general we will yeah, we'll be getting to the XRP shortly Yeah, okay Let's see, I've been fortunate in that I've been able to contact others to help me out Some of the challenges have been, for example, not knowing about electronics at first and having a friend teach me about electronics, learning JavaScript through online coursework out of MIT OpenCourseWare, things like that. And then falling into opportunities, excuse me, like a WPI.

Kellen: Okay, great. Great answer. So, on to the next question. How do you use technology in your teaching, and specific in XRP robotics, and what benefits did you see it offered to the students.

Corbett: Phenomenal.Phenomenal benefits. It's I teach robotics full time at the school, and there's one group of people and it is the majority of students that get into building the robots and then there's the other group, I'd say 40 percent who are into programming the robot.And the XRP addresses that with those students right now. And it's a big boy language or big girl language in that it's Python or Circuit Python versus a GUI interface.

Kellen: Great. That's a great answer.So next question.Do you think there is a gender bias in STEM education.

And if so, how do you what do you do to make sure everyone feels involved.

Corbett: There is a gender bias. I am an elective. Students are not chosen. Students do not choose to take my class, but are given my class.

Still, the attrition rate is such that I average one to two girls for every ten males.

Kellen: Well, all right. That's a question ratio for sure.

Corbett: Yeah, one of the things I've talked to the business tech teacher who does a lot on entrepreneurship is maybe doing an app development course for women. That's something they're interested in.

Kellen: That's a great suggestion, great point. All right, that's the next question.Were there any limitations in this course due to the class environment.

Corbett: No, none.

Kellen: Great, nothing reported on at all.That's great, no, that's great that you're hear. Yeah, all right, next question.

Can you describe any racial disparities you've observed in your STEM classroom.

Corbett: In the classroom. On race. No.You can go to DESE, the Department of Education and Elementary and Secondary Education to see the breakdown of English high school, but you'll see that we're pretty diverse.

Kellen: Did you notice like, so you've taught other STEM classes, right.

Corbett: Right.

Kellen: So did you notice like there was any was there did seem different in this class compared to any other classes you've taught.

Or do you think it was just about the same.

Corbett: This class holds the students up a caliber that I've never had to do before. So perhaps socioeconomic disparity.

Kellen: Wait, hold that thought.We're just about to get into that.

Corbett: Okay. Okay.

Kellen: Next question.How do you create a classroom environment that is inclusive to students from different socioeconomic backgrounds.

Corbett: Great question. Let me think. What I found is that a number of my students do really well in in my class but have no family support to go on to college. And then there's the whole mess of figuring out financial aid forms, things of that nature. One student -- >> [Inaudible] >> Hold on just a second. Yeah. >> [Inaudible] >> He's sick. I'm going to see you this afternoon.Yeah. All right, good. I'm back. The students don't have access to things that say, white collar families would have, you know, I mean, both my parents went to college, so it was expected that I would go to college and other families and other, you know, know, economic status.They may not. I have a student who does really well in this class, but she has a

son at home. And so wherever she goes, it's going to have to offer daycare. So it's very limiting. That's yeah.

Kellen: All right. So it's the next question, kind of a follow up question to that. In your experience, how have you seen socioeconomic backgrounds impact the way students approach STEM subjects.And can you make any accommodations to adapt to that.

Corbett: For socioeconomic.

Kellen: Would you like me to repeat that question.

Cobert: I'd allow the student to bring her child to school.

Kellen: Okay, yeah, so that's a great, yeah, that'd be a prime example, right, okay.

Great, so as the next question, how do you change your teaching methodology if a student falls behind.

Cobert: II give them access to everything I have. So just read access to everything I have and then ask them pointed questions.

For example, a student who missed the line following, I'll give them the documentation on line following, give them a map, a chart paper with a line on it to test their robot and allow them to bring home the robot to work on it.Then when they come back, they're very specific. You need to show me that it can follow this line.Does that make sense.

Kellen: Yeah. Yeah. So next question. Um, what do you do if a majority of the class understands the topic but a few students fall behind.

What would you do then.

Cobert: let the rest of the class go ahead and pull the ones, the few students that are falling behind and pull them up.

Also at the school, we have something called PIE, and I forget what it is, personal improvement something.

It's a 40 minute period every day where teachers and students can request to meet a teacher during the PIE period to catch up.

So the school schedules in a catch up period.

Kellen: Oh, okay, so there's a system in place by the school to kind of help with that.

Cobert: Yeah.

Kellen: All right, so this is kind of a more broad to the technology STEM education they've taught. What are some effective teaching strategies that you use to engage students in STEM. Like specifically that engagement part.Is there anything in particular you notice that engages students a lot when you're teaching.

Cobert: hands-on project base, all the buzzwords of today in terms of education. In other lifetimes outside of robotics, it's been giving the student an angle, giving them a background story that hooks them. And then here's the angle.For example, last year with middle school, I did space and worked a multidisciplinary course where I had students figure out what they were gonna pack and bring to Earth, I mean, to Mars, how much water they need to bring and do Google searches and that type of stuff. At the same time, the science teacher was teaching about the gravity difference between the two planets. And then the ELA teacher took a book on Journey to Mars and had the students read that so that it was three different teachers all doing a Mars STEM thing. So the teachers kind of coordinate what they're teaching with each other to kind of just make it easier for students.

Kellen: Right, gotcha, gotcha.All right. So more specific, this is got a question, more specifics, the XRP Robotics course. From your experience, what part of this course had the most engagement from students.

Corbett:I think the wall following the ultrasonic sensors.

Kellen: Interesting. What was the coolest.

Corbett: I'm going to, a friend of mine built me a sumo ring. So we're gonna do sumo wrestling.

I'm gonna do sumo wrestling. We'll see what that generates.

Kellen: That sounds fun.That sounds pretty engaging for the students though.

Corbett:- Yeah.

Kellen: All right, next question. What types of activities do you think the students are most engaged in.

Corbett: Like- - Anything competitive.

Kellen: Any, okay, so there needs to be like almost like a challenge aspect to it.

-Corbett: Yes.

Kellen: All right, interesting. Were there any particular challenging or difficult topics in this XRP robotics course that the students failed to grasp.

Corbett: Oh, the curriculum was really good.

Kellen: Great, thank you. Is there anything that you'd see that we need to do to change our approach to maybe teaching a certain subject within the course.Do you think there's, they noticed we might want to change something up ourselves.

Corbett: Well, I, I noticed there were things on, I guess, better coordination between the website and the Canva.

Is it Canva. For example, things like, you know, differential gear, yeah, wheel size and all that stuff, wasn't available on the website or vice versa.I don't remember which, but like one of them had it, one of them didn't. And it could be that AK had just written it and sent it to me early That could have been what the situation was. But there was some documents that I received outside of the canvas.

Kellen: Okay, great. Next question. So how do you, this is more for your STEM courses, how do you integrate critical thinking and problem solving skills into your teaching.

Cobert: That's easy, project-based learning. The wall following, for example, how do you make it make a right-hand turn without just spinning in circles. It works for going left hand turns, but it doesn't work when it's a right hand outside turn So students have to figure out how to tweak the code for that.

Kellen: Great.All right. Next question. So now this one's probably one to give a little thought. How do you assess student progress and then modify your teaching accordingly.

Well, it's interesting because last semester was without the XRP and most of my assessments were on the physical building of the robot.

This time most of my assessments are on the coding and having them figure out which sensor does what best for which task. So it's a much more room. instead of visually seeing that they've done these five things, we have it do, you know, does it do this, this, this, this, and this.

I guess, could I, could I send you a rubric from last semester and rubric from this semester.

Kellen: All right. Yeah, sure.Don't be in a rush to do that.Now we have a limited time with the Zoom meeting, But afterwards, if you want to do that would be much appreciated.Next question.So how, how do you motivate and engage students who might be disinterested in the subject.

Corbett: Yeah, it's tough isn't it. It is very tough. It's also why I say we're not an elective, even though the school calls me an elective I have, you know, a handful of students that just don't want to do robots. I threaten them with grades.I did something this last year that I may not do this year because I have four sections of robots and only one with the XRP. So the other three, I may not do this project, but it allowed students to work on their interests, such as write an elevator pitch for your prototype, put together a shopping list for what you needed.

Kellen: So it kind of subjects like kind of surrounding the matter, but maybe not always directly.

Corbett: Right.

Kellen: Gotcha, gotcha.Now this is kind of more a case specific question, but was there ever a case where you saw a disinterested student also on Switch and then become deeply interested in the subject. Did you ever notice something like that ever happened where they kind of just pull a complete 180 and then become like deeply invested in the subject.

Corbett: No.

Kellen: No.unfortunate. All right, next question.So how was the engagement in this XRP robotics course compared to the other STEM classes that you took.

Corbett: I told the students before I determined which class would get the XRPs. And the first period there was a large majority of programmers. So I went that way and they're interested, you know. Right.

Kellen: They, okay.So you pick the ones who, you cherry pick the ones who would want to actually be in the course.Okay. Now questions related to the XRP course again, how was the overall pacing of it. Do you think it was too fast or too slow at any points.

Corbett:I think it was too fast, which is why I'm bringing in sumo wrestling and other things.

I want them to 3D print attachments, things of that nature.

Kellen:How many times a week did the class meets and how long were the meetings.

Corbett: Five days a week, 55 minutes a day for a hundred for 90 days.

Kellen: All right, great. All right, we're about to be wrapping up this interview soon so if I have more questions, just to give you some perspective. So next question is how far did you get to the curriculum. Did you complete it or did you just- -

Corbett: No, not with the students. I have, but not the students.

Kellen: How, like about how far do you think you got into it then, rough percentage you think.

Corbett: I got two thirds.

Kellen: Two thirds. All right.Next question. Were there any specific parts of the course that gained the most attention and any specific parts that gained the least attention from the students.You did mention that ultrasonic sensor was pretty popular among the students.

Anything that like kind of dissuaded the students from the subjects.Anything very- -

Corbett: No, no.They were definitely into the exercise.Hold on a second.You're leaving.Okay.All right, go ahead. And then a question for STEM course in general.How do you encourage students to continue pursuing STEM education beyond the course.

Well, I had this really cool project going on.I got a grant for $10,000.And if you look up BrainCo, you'll see the robot hand and brain computer interface.And yeah, it's really cool.And we've got the private industry council paying the students and private industry council giving them paid internships this summer with STEM companies.And a lot of that has to do with, you know, me going up and saying it, but pick heard about it and said, we want to support you.

And I said, we want your money.

Kellen:That's great.That's a great way to motivate the students.That's for sure.They definitely want to be in touch with that.Wow. So how do you connect your curriculum though with real world experiences and applications.Is there any specific way in which they do that.

Corbett: We've been getting donations this year.For example, I got a EOD, explosive ordnance device, from the fire department, who got it from the Department of Navy. And the Navy had used it in Iraq. So I've got like 10 students all over this and asking, when am I bringing in the bombs. I said, now I'll bring in a backpack, you know, that you have to open up and take the craft out of. But yeah, so real world applications.

Kellen: That'd definitely take my interest for someone to engage first here.

That'd be pretty cool. Anyways, next question. if you had to do it again, what changes would you make in the, in your teaching style in particular to improve the quality of the course.And then I was going to ask right after what changes can we make.

Corbett: Um, I guess what I'd like to see what changes I've made, um, were the rubrics, talk of quizzes, and they weren't available, so I had to make my own.I would love to see what others have made.So are you familiar with the Scratch ecosystem.MIT Scratch.

Kellen: Scratch system.What is it.I'm not aware of it.

Corbett: I put it in the chat.

Kellen: Okay, great. Yeah, I wonder if the attendees can see that. Okay, great.

Yeah, we'll have to definitely look into that.

Corbett: That, they have a whole ecosystem, including where teachers can post things and ask questions of each other, where students can post things and ask questions of each other. So when a student's got an assignment at home and they're stuck, they can go onto the message board and communicate.But it's global.it's, it's, you could learn a lot from scratch.

Kellen: Yeah.That's great.Didn't even know about it. And then a final question.Um, overall did the Robux XRP Robotics course meet your expectations.

: Exceeded.

Kellen: Exceeded.Wow. Great to hear.

Um, and I think I believe that is it. Um, thank you for your time.Thank you for your thoughtful answers.We really appreciate it

Corbett: Sure.

Appendix B:

Nick Greely Interview Notes:

1. What are some things that you needed to consider when choosing the pilot school?

   Prior partnership - Background of the school (worst-rated school in Mass) - Approval of the teacher - Follow the guidelines of the DEI for WPI - students want to be there
2. Has there been other classes similar to this one at the pilot school? Other STEM classes?

   Prior experience teaching robotics, no experience teaching this kind of course - Prior class wasn't sustainable
3. What qualifications did the teacher for the current pilot course have that made them the best choice to teach it?

   Been a STEM teacher for 30 years - involved with STEM advocacy
4. What are some things that you have done to help the teacher prep for the course?

   Walked the teacher through the curriculum, extensive training for course - constant support throughout the class
5. Is the current pilot being taught as a class or as an afterschool activity. How does this affect the way the class is taught or how the teacher prepares for it?

   1st period class (7:15 class) - Likely wouldn't affect preparations/execution
6. How many robots is the current pilot using and what is the ratio of students to robots? Do you feel that this ratio of students to robots works for should it be lower or higher?

   Currently 17 robots, 1:1 ratio, no more than 1:2
7. What technology is being used to teach this course, is it beneficial or did it create more problems?

   Logic board (MakerPi board), custom boards, sensors - No trouble (except for broken boards for replacements)
8. What were some difficulties you ran into when implementing the course into the pilot school?

   Relatively smooth integration - Provided robots, signed contracts, email communication
9. Is there anything that you would have added to the pilot course to make it run smoother?

   Developing educational videos (assembly, diagnosing issues, programming, optimizing sensors)
10. In your opinion what shows that the course is successful?

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